THE ESTIMATE
COST OF A CONCRETE BUILDING

BY

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ARMOUR INSTITUTE OF TECHNOLOGY

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Estimate cost of a concrete
 building

ESTIMATE COST OF A CONCRETE BUILDING

A THESIS

PRESENTED BY

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The Estimate of the Cost of a Concrete Building.

The necessity to know the cost of a structure, after the plans have been drawn up, is to put engineering designs and computations in language that the business man or layman is able to perceive instantly, if that is what is desired.

Buildings, more than any other kind of structure require an estimated cost for the reason that the men most interested in its design and completion are not of an engineering profession and are not trained to think along mathematical lines.

After the plans of a building have been compiled by an Architect, it is an engineer's problem, not only to design the steel work, but at the end to make an investigation of the cost of the building, which will enable himself, or his employer, to select a contractor, whose figure most closely approaches the cost estimated.

The same method as was used for the estimate of the foregoing plans may be used for a building of any size. A factory building was taken, therefore,

24134

of moderate size. The lot on which the building Stands is 125'-6"x100'-6", a part of the land of the Carter White-Lead Company.

The building is three stories of fire proof construction. The steel work is of "Bethlehem" sections requiring a fire proof covering of all steel.

The building is of heavy construction, because of the weight of machinery to be palced in it; used for the manufacturing of the white-lead paint made by the "Carter" method.

The flooring is of concrete slabs reinforced in two directions, except in slabs near tanks or vats coming through the floor where it is reinforced in four directions.

The first floor comprises a fill of 2'-6", which will be taken care of by acting as a place of disposal for cinders from the boilers of the power plant, during the construction of the steel work of the building, thereby, eliminating haul of filling Material.

The companies switch from the Illinois Central R. R. and also from the Pennsylvania R. R. which is located directly in the rear of the building will be convenient for unloading steel, shipped from the mill.

This also enables all material to be unloaded with convenience doing away with teaming charges.

Prices for all materials were inquired into and accepted after being compared with bulletins of the prices published in "The Engineering News." The steel was figured from separate items of labor in the fabrication of steel, and in the separate cost of erection. It was thought impractical to investigate the cost of the different items that came under heading "Fabrication" because of the time limit.

The prices of the fabrication of steel was taken as given by the mills and to that was added the labor and cost of the erection, per ton of steel. The cost of steel erection is harder to analize than it may at first appear, for the reason that more delays occur as the work progresses than any other kind of contract work.

The Chicago Building Union table of wages per hour were used to estimate the labor on the different

divisions of the contract. The books referred to were Gillettes "Handbook of Cost Data," and, Taylor and Thompson's "Concrete Costs."

The Estimate is divided under the following heads

(1) Estimate of Labor.

(2) Estimate of Material.

(3) Estimate of Labor on Forms.

(4) Estimate of Finishings.

Design and arrangement of contractors plant for steel erection.

Design and arrangement of concrete forms and mixing plant layout.

Estimate of Labor.

The cost of labor per cu. yd. was based on wheeling material in wheelbarrows to a 4 bag-batch mixer and dumping concrete to place from wheelbarrows.

The outline given in "Concrete Costs" by Taylor and Thompson were followed in this part of the estimate. Table-69, p.-439 was used. That is, the columns contained 292 cu. yds. of 1:2:4 concrete

at $1.78 per cu. yd.=$519.76, Labor at 40¢ per hr. The tables were made out for Labor at 20¢ per hr. The column in table headed, "Concrete Discharged into Barrows," was taken. The cost included wheeling material 50 ft. to mixer, charging mixer, mixing machinery and plant charges, wheeling concrete, 50 ft. wheeling, placing and tamping concrete, also includes 15% for foremen 15% for extras for superintendent and Labor at 40¢ per hr.

Total cost of Labor 20¢	$0.73	Labor at 40¢ / hr.	$1.4
Plant cost	.20		.20
Plant cost Barrows & Tools	.09		.0
Fuel	.03		.03
	$1.05 / cu. yd.		$1.78

The Estimate of Materials.

In the Estimate of Materials, concrete was taken at the value of $1.58 per bbl. Sand @ 75¢ per cu. yd. Stone @ $1.00 per cu. yd.

The table on page 167 was used. The cost of material for one cubic yard of 1:2:4 concrete. The cost of material was taken as delivered on the job.

The tables are based on the following assumptions:-

Portland cement is taken as 4 bags equal one bbl. weighing 376 pounds net or 100# per cu. ft. The stone is taken to pass through a 1/2" ring and to contain 45% voids and measured by the cu. yd.

The sand is taken in bulk in its natural state and at the average weight of 100# per cu. ft. The table gave $3.715 which was taken at $3.72 per cu. yd. and this price multiplyed by the 292 cu. ft. gave the cost of the material in the columns, which amounted to $1086.24. The unit cost of the materials in the beams was the same as in the columns as also in the slabs.

Estimate of Forms and Labor on Forms.

The fisrt item to be considered under this head is the material in the forms.

Steel does not lend itself readily to building construction, because of the variety of design in the buildings and also no two buildings are of the same size. The shape and size of building are controlled to a great extent by the conditions they are to be built under. This makes it impractical for steel forms to be used. The expense of the steel forms prevents their use even in jobs such as tunneling.

Lumber for forms most be free from knots (as much as possible) also shakes and rots. The knots will show on the finished surface of the work, also causeing the lumber to be weak. Partly dry lumber is better than kiln-dried for the reason that the kiln-dried swell and bulge at the joints; it is better than green lumber, which will shrink as the concrete dryes out and therefore must be kept wet.

The lumber should be dressed on all four sides. Tongue-and-grooved stock is most common for sheating, for the reason that it can be used over and over again and gives a smoother surface.

The dimensions of

Posts, joists and studs are governed by the size of the beams or griders they are to hold up, and were taken at posts 4"x4" spaced 4'-0" c. to c.

The personal experience of the contractors have been to take 1" lumber, that is, 7/8" dressed for column forms and beams. Thicker material would permit wider spacing of joists and posts, but the saving of lumber is not great enough to be considered as an

advantage over 1" sheeting. For the bottoms of the beams and girders some have used 2" stock (1 3/4 after dressing) which gave better results than 1" stock. For columns 1" sheeting was used also for beams and girders and floor slabs, because material of the same thickness is easier to use a second time than if a different thickness was used in several different places.

The use of old lumber versus new in form construction is becoming a question of the utmost importance due to the great increase in the cost. Contractors using form work are beginning to use lumber until worn out, (that is when the pieces are to small to use) regardless of the cost of remaking which runs the cost of making 90% greater than making forms of new lumber.

Number of times to use forms controlls the cost to a large extent and should be carefully considered. The number of times forms are used, depends upon the height and size of the building. For a three story building the sets of the forms made up the first time should consist of 1 1/2 sets.

That is the forms of the first floor with the columns of the first story should be made; also the slab forms of the second story, and half second

story columns and girders should be made up, so that the carpenters will be busy and work progressing, while the concrete in the one set of forms in drying.

The time that forms should be removed depend upon the weather, character of the members and the span. A long span girder must be supported a longer time than short span girder.

As a guide to practice, the following rules are taken from "Taylor and Thompson Concrete Cost." Walls in mass work, 1 to 3 days until it will bear presure of thumb.

	Summer	Winter
Columns	2 days	4 to 6 days.
Slabs up to 7'-0" span	6 days	2 weeks.
Beams & girder sides	6 days	2 weeks.
Beam & girder bottoms & long slabs	10 da. to 2 wk.	3 wk. to 1 mo.

Care should be taken in the summer in removing the forms and if the weather has been damp the time taken to dry out should be longer.

In the design of the forms the foreman or superintendent

should be consulted as also the draftsman. To leave the design of the concrete form absolutely with the foreman is to have a form too easily taken down, (that is it will not hold the concrete in place while drying) and on the otherhand the draftsman may make a form of such a pattern as to waste material, (through ignorance of practiced methods).

The forms should be built from plans in order to further the saving of time and material.

For the removal of forms the most convenient and logical order is

(1) Column sides
(2) Joists
(3) Girder sides
(4) Beam sides
(5) Slab bottoms
(6) Beam & Girder bottoms

The wall forms are not used in this building.

The building estimated, second story columns are shorter than the first and third. This causes a great expense in Labor due to making the columns short and then lengthening the columns again for the third story.

Note on Construction.

In the design of the floor slabs and columns, economy is best obtained by having all columns and floor slabs the same dimensions. The relative strength being obtained by verying the percentage of reinforcing. A note given by "Taylor and Thompson" from Mr. Leonard C. Wason, states that in one case the saving in concrete by reducing the size was $2.30 per column; on the other hand, the increase in the form cost was $5.70 per column, entailing a loss of $3.40 per column. The computations for a like condition by "Taylor and Thompson" give the loss per column at $3.37, thus checking the figures given by Mr. Wason.

Form Construction.

The Form Construction divides itself into the following divisions of work, making, handling, erecting and removing and thus is divided again into definite operations.

The carpenters should consist of gangs of 2 men each.

Each gang should repeat the same work over and over. The method best to follow is to have each gang make a column side and repeat on each floor; also set columns; brace columns; set posts; set beams and attach end of beams to girders, and so on.

The idea in the systematizing of the labor on a job is to have all gangs working steadily and not interferring with each other. The time required by the different gangs to preform a piece of work should be as nearly equal as possible. Each man should become accustomed to his division of the work and grow expert; and have a feeling that he must work steadily to keep up with the gang ahead, or out of the way of the gang behind.

Laborers carry all materials, supply the carpenters with blocks, wedges and bracing lumber, also remove the forms after the concrete has been placed. The concrete mixing gang, on small jobs do all the carrying of lumber and removing of forms. They require a first-class boss, unless watched every minute, will work simply to kill time.

On all jobs if the costs estimated is above $20,000 for Labor and material, a circular swing arm saw and a table saw will be economical. The men who run the saw can work on other divisions of the labor when not busy. If the saw is run by a gas engine; to avoid the raising and lowering of the forms from above floors the plant should be raised to that floor. On all floors it is economical to have plenty of staging.

The method of erection is to nail the three sides of the column form together at the ground and fit the fourth side after being raised in place.

Method of Erecting Beam Forms.

The best method to follow is to make the bottom of the form the net width of the member and have the side project down. The forms to be put together and raised in place as one member and connected in their relative positions. The setting of the forms by this method may be done by a gang of laborers; and carpenters wages saved. In fire proof construction the forms are held in place by wire being passed over

the "I" beam and through the bottom of the form; one-fourth inch round wire being used. Wire netting is fitted around the bottom of the flange to reinforce the strip of concrete under the lower flange.

The erection of Slab forms.

The slab forms are build similar to the laying of a floor. The joists and stays being erected first. The slab surface being constructed of plank lumber or corrugated sheet iron; which is laid on 3"x 8" stringers or 2"x 4" joists. Boards 1"x 8" being used if lumber sheeting is to be the covering. To the sides of the beams and girders are attached "ledgers" on which the slab form may rest, also being braced by posts, usually 4"x 4" being used.

In the removal of forms it is often advantageous to wait until the concrete is completely set and remove the beam and girder form in one piece and use for a beam and girder of like dimensions on the floor above.

Mixing Concrete and Mixing Plant.

In all construction work the orginization of the different gangs of laborers, in that they will become a constant factor in the cost, is the essential item in planning the layout and work. It is impossible to arrange a steadfast system in regard to rough labor; for the reason that the time for the different operations cannot be obtained (with accuracy). The best method to follow is to understand the operations in a general way and make a plan of the work before construction starts and let the foreman of that division use his experience and knowledge in changing the plan to suit the conditions.

The first item to consider under the mixing of the concrete is the transportation of raw materials.

The sand stone, and cement is to be conveyed to a platform near the work. The platform is to be flush with the opening of the mixer inorder to allow the materials to be dumped into the mixer without waste of energy and time. The discharge opening of the mixer should be convenient distance above the ground asto discharge into a wheel barrow which is to be wheeled

to the point of placing of the concrete. The material when to be placed in the second floor will be elevated by a small elevator, one wheel barrow man working on the ground and another on the second floor. The man on the ground wheeling the barrow to the elevator and placing it there on. Sends it to the second floor where it is received and wheeled to place; he returning with the empty wheel barrow and placing it on an elevator which descends to the ground floor at the same time receiving another wheel barrow which has ascended, the man in the meantime has taken the wheel barrow, which has descended, to the mixer to be filled. Three gangs are able to use one elevator, that is, 6 men will keep the elevators in constant use. The same operation is preformed on the third floor and roof. The allowance for delays in wheeling the materials to the mixer was taken at 50% extra. This large allowance is necessary because of the difficulty in arranging a gang of mixer chargers to work steadily. To charge the mixer without delay, the gang of wheelers must be so arranged that they can supply enough sand and stone for one batch of concrete without reloading.

The type of mixer used was a rotary mixer, and was charged by throwing the concrete, sand and stone also water in a shute which threw them against deflectore. The mixer may be used as a four batch, or continous mixer, discharging into a wheel barrow or cart as the case may be. In the estimate the account wear and tare under the head of machinery.

Brick Work.

The curtain walls are of brick on the North Side the building, of which there are twelve panels, 1 1/2 laborers to each brick mason were allowed. The laborers mix the mortor and carry it and also the bricks to the mason using hods for the purpose. Each hod holding 18 bricks or about 100#.

The wages were taken Chicago union scale

Bricklayers	72 1/2 ¢
Hod Carriers	40 ¢

The windows constructed by the United States Steel Window Company and the cost was figured at 25¢ per sq. ft. to which was added $4.00 for every transom.

Weight of Steel

Description	Shape	Size	Weight per foot	Length	No. Req'd	Weight	Remarks
Wall Columns	H	10	59½	18'-11¾"	28	31 654	
Interior Columns	H	12	84½	18'-11¾	29	46 560	
" "	H	12	112	18'-11¾	6	12 708	
Second Floor Framing Plan							
Wall Floor Beams	I	15	71	117'-4"	8	8331	East Wall
" " "	I	15	71	117'-4"	8	8331	West Wall
" " "	I	15	41	93'-2"	6	3820	North Wall
" " "	I	15	41	93'-2"	6	3820	South Wall
Interior Girders	G	18	92	15'-2"	5	6976	Running N. and S.
"	G	18	92	15'-2"	5	6976	" " "
"	G	18	92	14'-6"	25	33350	" " " "
"	G	15	71	14'-6"	3	3089	" " " "
"	I	15	41	16'-7"	46	31308	Running E. and W.
"	I	15	41	16'-3"	82	54633	" " " "
"	G	24	120	16'-3"	4	7800	" " " "
"	I	12	28	15'-4"	2	858	" " " "
Second Story			Total	=		260,213	260.213
Wall Columns	H	10"	49	14'-3"	28	19,551	
Interior Columns	H	12"	71½	14'-3"	35	35,665	
Third Floor Framing Plan							
Wall Floor Beams	I	15"	71	117'-4"	8	8331	East Wall
" " "	I	15"	71	117'-4"	8	8331	West Wall
" " "	I	15"	41	93'-2	6	3820	North Wall
" " "	I	15"	41	93'-2	6	3820	South Wall
Interior Girders	G	18	92	15'-2	10	13953	Running N. and S.
" "	G	18	92	14'-6"	30	39,551	" " " "
" "	I	15	41	16'-7"	46	31308	Running E. and W.
" "	I	15	41	16'-3"	92	61295	" " " "
				Total Wt =		222624	222.624
							482837#

Description	Shap	Size	Wt per ft	Length	No Req'd	Weight	Remarks
Third Story							
Wall Columns	H	10	49	18'-9"	18	16 538	
" "	H	10	49	19'-9"	4	3871	
" "	H	10	49	20'-9"	4	4067	
" "	H	10	49	21'-9"	2	2131	
Interior Columns	H	8	32	19'-9"	14	8848	
" "	H	8	32	20'-9"	4	2656	
" "	H	8	32	21'-9"	2	1392	Pent House Columns
" "	H	8	32	27'-3	10	8720	" " "
" "	H	8	32	28'-3"	5	4550	" " "
Roof Framing Plan							
Wall Beams	I	15	71	117'-4"	16	16,661	
" "	I	15	41	93'-2"	12	7,640	
Interior Girders	G	8	18	15'-7"	22	6172	Running North and South
" "	G	8	18	15'-4"	22	6070	" " " "
" "	G	8	18	15'-4"	36	9934	" " " "
" "	I	12	28	16'-7"	14	6500	Running East and West
" "	I	12	28	16'-3"	28	12,740	" " " "
Pent House Roofing Plan							
Beams	I	8	18	58'x2		2088	Running North and South
"	I	8	18	61'-4"x3		3312	" " " "
"	I	12	28	32'-6x5		4550	Running East and West
				Total =		128,440	
Weight of Steel = 611,277# = 305.63 Tons							

Description	Cu in of steel	Cu ft of steel	Weight per foot	Weight per Shoe	No Reqd	Weight	Remarks
Shoe Mkd. A	2160	1.25	450	562.5	29	16 313	On Interior Column
Shoe Mkd. C	2420	1.40	450	630	6	3780	
Shoe Mkd. B	600	.35	450	192	4	768	
Shoe Mkd D	600	.35	450	192	24	4608	
Connections	No	Size	Wt/ft	No/Reqd	No Columns		
Wall Connections Ls 6"x4"x 7/16		15"	14.3	6	24	2574	
Corner Wall Connections	Same size Ls	15"	14.3	4	4	286	
Interior Wall Connections	Same size Ls	15"	14.3	8	35	5005	
						7865# X 3	(For three Floors) = 23,595
Pent House						1512	
Tie Rods 3/4"	Wt perft	No of Ft	Wt				
" " "	1.502	500	750				
	"	220	330				
		750	1127				
		260	391				
		540	811				
		800	1202			4611#	
			Total	Wt	=	55187 =	27.6 Tons
Rivets	No/Reqd		No/Col	Total No Reqd			
Wall Columns	54		24	144			
Interior Columns	72		35	1296			
Corner Columns	36		4	2520			
				3960	x 3	(For three Floors) = 11880	
Weight of 100 Rivets = 120.7# x 118.80 = 14339# = 7.18 Tons							
Total Wt of Iron and Steel = 340 Tons of Steel							
							Steel Erected = \$55.00
							Freight on Steel from
							Pits. to Chi. \$.18/c
							Cost of Steel in Place
							540 Tons x \$55.00 = \$18,700

Story	Dimensions	Number of Members	Material		Ref Page	Labor		Remarks
			Per Member	Total		Per Member	Total	
	Columns							Cost of Labor per cu.yd based on
	1st Floor Fill	0			527			wheeling material in wheelbarrows
1	18"x18"x19'	63	43	2709				to 4 bag batch mixer and dumping
2	18"x18"x19'	63	43	2709				Concrete to place from wheelbarrows
	Wall Columns							
3	18"x18"x19'	18	43	774	527			Material 1:2:4 Concrete) Table 31 p.167
3	18"x18"x20'	4	45	180				Cement @ 1.58 per bbl } $3.72
3	18"x18"x21'	4	47¼	190				Sand @ .75 cu.yd per cu.yd
3	18"x18"x22'	2	49½	99				Stone @ 1.00 cu.yd
	Interior Columns							∴ 292 cu.yds. @ 3.72 = $1086.24
3	14"x14"x20'	14	27	378	527			
3	14x14x21	4	28.56	114				Labor- Table 69 p.439
3	14x14x22	2	30	60				292 cu.yds @ $1.78 = $519.76
	Pent House Columns							Labor @ 40¢ per hr
	16x16x27	10	48	480				
	14x14x28	5	38	190				
				7883 cu.ft				
				291.8 cu.yds				

Story	Dimensions	Number of Members	Ref Page	Material Per Mem	Material Total	Labor Per Member	Labor Total	Ref. Page	Remarks
	Column Forms	1'	Sheathing		Ft B.M.				Carpenters Wages Union Scale
	1st Floor Fill	0				$ Making	$		Chicago 65¢/hr $\frac{65}{50}$ = 1.3
1	18"x18"x16'	63	620	334	21,042	4.81	303.05		Making
1	18"x18x16'	63				11.10	699.30		Place & Remove 1st Time
2	18"x18"x14'	63				9.27	584.02		after First Time P&R
3	18"x18"x18'	18		377	6800	12.01	216.18		M. P&R 1st Time
3	18"x18"x19'	4				10.68	42.72	633	Remake P.&R.
3	18x18x20	4				11.28	45.12		" " " "
3	18x18x21	2				11.50	23.00		" " " "
3	14x14x20	14				13.77	191.78		Remake Place Remove & Cut
3	14x14x21	4				14.07	56.28		" " " "
3	16x16x26	10				19.34	193.40		" " " "
3	14x14x28	5				20.33	10.165		" " " "
3	14x14x22	2				15.99	31.98		" " " "
							2488.48		

Floor	Dimensions	Number of Members	Ref Page	Material Member	Material Total	Labor Member	Labor Total	Remarks
Running E & W	Beams							
	Depth below Slab							
1.	Fill 3'-6", 6" Slab							Material 1:2:4 Concrete
2	12"x16"x16'-1"	16		21.3	344.5			105 cu yds @ 3.72 cu yd = $390.60
"	12"x16"x16'-1"	16		21.3	344.5			Labor @ 40¢/hr
"	12"x16"x15'-1"	7		20.0	140			Labor 105 cu yds @ 1.78
"	12x16x15'-1"	7		20.0	140			add .05 for elevator @ 1.83 =
"	12"x16"x16'-3"	16		21.6	346			192.15
"	12"x16"x16'-3"	16		21.6	346			
"	12"x16"x14'-9"	7		19.7	137.9			
"	12"x16"x14'-9"	7		19.7	137.9			
"	12"x15"x14'-9"	4		18.4	73.6			
"	12"x15"x16'-3"	2		20.3	40.6			
"	12"x16"x16'-3"	12		21.6	259.2			
"	12"x16"x16'-3"	12		21.6	259.2			
"	12"x16"x14'-9"	3		19.7	59.1			
"	12"x16"x14'-9"	3		19.7	59.1			
"	15"x24"x14'-9"	4		37.0	148.0			
					2835.8 cu ft = 105 cu yds			
Running N & S	Girders							
Floor 2	24"x18x14'-1"	10		42.25	422.5			Material 1:2:4 Concrete
	24x18x13'-10"	27		41.5	1120			Labor 1.83/cu yd x 105 = 192.15
Running E & W	Wall Beams							105 cu yds @ 3.72 = $390.60
	12½x36x14'-7"	4		47	188			
	12½x36x15	8		46.3	370.4			
Running N & S	Wall Beams							
	13"x36"x14'-1"	4		45.8	183.2			
	13"x36"x13'-10"	12		44.5	534			
					2818.1 cu ft = 105 cu yds			

Floor	Dimensions	Number of Members	Ref Page	Material Member	Material Total	Labor Memb	Labor Total	Remarks
1	Beams							Making 16' Beams $2.25
1	Fill			Ft B.M.			276.00	Making 15' Beams $2.12
2	12"x16"x16'	16	647	173	2770	2.61	5429	2.25x88 = $198 } $276
	12"x16"x16'	16		173	2770	2.61	54.29	2.12 x 37 = 78 }
	12"x16"x15'	7		162	1134	2.48	2257	Place and Remove 1st Time
	12"x16"x15'	7		162	1134	2.48	22.57	Multiply by 1.3
	12"x16"x16'	16		173	2770	2.61	54.29	
	12"x16"x16'	16		173	2770	2.61	54.29	
	12"x16"x15'	7		162	1134	2.48	22.57	
	12"x16"x15'	7		162	1134	2.48	22.57	
	12"x15"x15'	4		159	636	2.61	13.57	
	12"x15"x15'	2		159	318	2.61	6.79	
	12"x16"x16'	12		173	2080	2.61	40.72	
	12"x16"x16'	12		173	2080	2.61	40.72	
	12"x16"x15'	3		162	486	2.48	9.67	
	12"x16"x15'	3		162	486	2.48	9.67	
	24"x15"x15'	4		203	812	2.73	14.20	Total Labor = 276.00
	Total	B.M	Ft		22514		$718.78	= Total of Labor & Making
2	Girders			Ft B.M.				
	24"x18"x14	10		189	1890	2.57	33.41	Place and Remove
	24"x18"x14	27		189	5100	2.57	90.35	1st Time
	12"x36"x15	4		233	932	2.81	14.61	Cost of Making 24" I
	12"x36"x15	8		233	1864	2.81	29.22	$2.22
	13x36x14	4		218	872	2.81	14.61	Cost of Making 15" I
	13x36x14	12		218	2516	2.81	43.84	$2.20
		Total	B.M.Ft	13174			$226.04	Total cost of Making
								= 143.74
								226.04
								$369.78

Floar	Dimensions	Number of Members	Ref Pag	Material		Labor		Remarks ⑧
				Memb	Tota	Memb	Total	
3	Beams							
	12"x16"x16'	23	647			4.15	95.45	Posts 4"x4" 4ft o.to c.
	12"x16"x16'	23				4.15	95.45	P. R. & C.
	12"x16"x16'	46				4.15	190.90	25% allowed for
	12"x16"x16'	46				4.15	190.90	waste of Material
	Girders							
	24"x18"x14'	10				4.22	42.20	
	24"x18"x14'	30				4.22	126.60	
	12"x36"x16'	4				4.58	18.32	
	12"x36"x15'	8				4.58	36.60	
	13"x36"x14'	4				4.56	18.24	
	13"x36"x14'	12				4.56	54.72	
				Total		867.50		
Roof	Beams							
	10"x9"x15'	6				2.82	22.08	Posts 4"x4" 4ft o to c
	10"x9"x14'	5				2.72	17.70	P. & R. & C
	10"x9"x15'	6				2.82	22.08	To get Total
	10"x9"x14'	5				2.72	17.70	multiply all by 1.3
	10"x9"x15'	28				2.82	103.09	∴ 2.82 x 1.3 x 6 = 22.08
	10"x9"x14'	30				2.72	106.20	
	Girders							
	18"x11"x15'	14				3.06	55.72	
	18"x11"x15'	14				3.06	55.72	Size of Beam 15"
	18"x11"x15'	14				3.06	55.72	
	13"x24"x15'	4				3.40	17.68	Size of Beam 24"
	13"x24"x15'	8				3.40	35.36	
	13"x33"x14'	4				3.25	16.88	
	13"x33"x14'	12				3.25	50.64	
				Total		$ 576.57		

Floor	Dimensions	Number of Members	Ref Page	Material Member	Material Total	Labor Member	Labor Total	Remarks ⑨
3	Beams			cuft	cuft			
Running E+W	Below Slab							Material
	12"x16"x16'	23		21.3	495			Concrete 1:2:4
	12"x16"x16'	23		21.3	495			Cost 3.72/cu yd @ 220=
	12x16x16	46		21.6	988			$818.40
	12"x16"x16'	46		21.6	988			Labor @ 1.83x220=402.60
Running N+S	Girders							
3	24"x18"x14'	10		42.3	420.3			
	24"x18"x14'	30		41.5	1245			
Wall Beams Running E+W								
	12½"x36"x15'	4		47.1	188.4			
	12½"x36"x15'	8		46.1	368.8			
Wall Beams Running N+S								
	13x36x14	4		45.8	183.2			
	13x36x14	12		45.0	540			
					5911.7	= 220 cu yds		
Roof	Beams							
Running N+S	10"x9"x15'	6		9.45	56.70			
	10"x9"x14'	5		8.85	44.25			
	10"x9"x15'	6		9.45	56.70			Concrete 1:2:4
	10"x9"x14'	5		8.85	44.25			Cost 3.72 x 98.5 = 366.42
	10x9x15'	28		9.60	268			Labor 1.83X98.5 = 180.155
	10"x9"x14'	30		8.85	265.5			
Running E+W	Girders							
Roof	18"x11"x15'	14		20	294			
	18"x11"x15'	14		20.7	290			
	18"x11"x15'	14		20.7	290			
Wall Beams Running E+W								
	13x24x15	4		32.6	130.4			
	13x24x15	8		32	256			
Wall Beams Running N+S								
	13x33x14'	4		41.9	167.6			
	13x33x14'	12		41.1	493.2			
					2656.6	cuf = 98.5 cu yds		

Roof	Dimensions	Number of Members	Ref Page	Material Member	Material Total	Labor Member	Labor Total	Remarks
Running N+S	Beams Below Slab							
	10"x9"x14'-11"	6		9.28	50.68			
	10"x9"x15'-4"	6		9.6	57.6			Material
	18"x11"x15'-3"	6		21.0	126			Concrete 1:2:4
Wall Beams Running N+S								Cost 3.72 x 337 = 1253.64
	10"x22"x14'	8		21.4	171.2			Labor 1.83 x 337 = 616.71
Wall Beams Running E+W								
	10"x22"x15'	4		23.3	93.2			
	12"x10"x32'	1		27.3	27.3			
Floor	Slabs							
1	6"x122'x97'			59.2	5920			Inside to Inside of Walls
2	3¾x122'x32'				1220			
	5"x46'x33'				595			
	3¾x122'x32'				1220			
	3¾"x76'-4"x32'			766	766			
Subtract for Openings								
	14'4"x10x2				-1101			
	$\pi \times (17)^2 \times 24 \times 3\frac{3}{4}''$				-47.5			
	$\pi \times (2.4)^2 \times 4' \times 3\frac{3}{4}''$				-15.7			
Floor		Total cu ft = 9087.8 = 337 cu yds						
3	3¾x122x97			3680				
Subt	15"x3¾x65	2		-50.5	3629.5			Subtract for openings
Roof	3½x122x97			3320				in floor
Subt	32'-6"x61'-4"x3½"			-576	2744			Material
Pent House Roof	3½"x35'-6"x64'			660	660			Concrete 1:2:4
Fire House Roof	3½ x11'-2"x4'2"			13.4	13.4			Labor 1.83 X 515 = 942.45
Curtain walls + Foundation								Cost 3.72 x 515 = 1915.80
Column Footings of Wall	8'x2'x2'	4		32	128			
	8'x3'x2'	24		48	1150			
Curtain Walls	13"x14'-1"x8	4		121	484			
	13"x13'-1x8	4		113	452			
	13"x13'-3"x8	12		107	1284			
	13"x13'-3"x8	8		115	920			
Footing Wall	1'-8½x102'-9	4		445	890			No Forms Used
Interior Col. Foot.	3'x3'x3'-4"	65		23.3	1520			" " "
		Total cu ft 13875 = 515 cu.yds						

Flour	Dimensions	Number of Members	Ref Page	Material		Labor		Remarks
				Member	Total	Member	Total	
Roof						$	$	
Pent House	10"x9"x15'	6	647			3.68	22.08	
	10"x9"x15'	6				3.68	22.08	
	18"x11"x15'	6				3.98	23.88	
	10x22x14	8				4.13	33.04	
	10x22x15	4				4.16	16.64	
	12x10x33	1				4.47	4.47	
							122.19	
	Slabs	Area sq.ft.		Per Sq ft	Ft.B.M.	Making/100 sq f .99¢		2.5 ft. B.M/per sq.ft.
Floar 1	122-1"x97-1"	11834	619	2.5	29,585	.99¢	117.16	1" Lumber 3 Panels/Bay
2	46x33	1518		2.5	3795	Placing/100 sq.ft		
2	76x33	2508		2.5	6270	3.08	364.45	P+R 1st Time
2	122x33	4026		2.5		2.26	267.48	Same size Column P+R 1st Time
Subt	for openings	-209			Ft B.M.	2.40	284.02	Column Reduced P+R+C
Floar 2	Total	11625		2.5	29063		1033.11	Total for Floar 2.
Roof	125x100	12500	617	2.5	31250	.99	123.75	Making/100 sq ft.
Pent House	64x36	2304		2.5	5760	2.40	55.30	C+P+R 12500 sqf = $300.00
Fire Hose Roof	11x4	44		2.5	110		1.06	
							300.00	
				Sq.ft	100/sq ft	$	480.11	
Wall 13" of Foundation	14'x8'	4	2 Surfaces	896	2.29	2.29	20.52	C+P+R
	13'x8'	4		832	1	4.91	40.85	1st Time P+R
	12'x8'	12		1152		4.91	56.56	after 1st Time P+R
	13x8'	8		832		4.91	40.85	" " " " "
							$158.78	

Floor	Dimensions	Number of Members	Ref Page	Material Member	Material Total	Labor Member	Labor Total	Remarks ⑫
Curtain Walls			169	Sq ft in Wall				
3	1'x 12'	2	439	24	Total	Cost x 2		For two Walls N & S 3rd Floor
	1'x 12'	8		96				
	4'x 15'	2		120				
	4 x 15'	4		240				
2	1'x 9'	2		18	Total	Cost x 2		
	1'x 9'	8		72				
	2'x 16'	2		60				
	2'x 15'	8		240				
1	1'x 12'	2		24	Total	Cost x 2		C. R & P per/100 sq ft $9.82
	1'x 12'	8		96				9.82 x 21 = $206.22
	1'x 15'	2		30				
	1'x 15'	4		60				
				1050	sq ft	x 2 =	2100	
E & W	Curtain Walls							
3	12'x 1'	4		48				
	½ x 12'	12		72				
	4 x 16	2		128				
	4 x 15	6		360				
2	1'x 9'	4		36				Labor on Forms
	½ x 9	12		54				C. P & R per/100 sq ft $9.82
	2 x 16	2		64				
	2 x 15	6		180				9.82 x 30.10 = $295.58
1	1 x 12	4		48				Total Cost of Labor
	½ x 12	12		72				on Forms $7300.00
	1 x 16	2		32				
	1 x 15	6		90				
Pent House	3'x 1'	4		12				
	1½'x 15'	2		45				
	1'x 15'	2		30				
	3 x 1	8		24				
	1½'x 15'	4		90				
	2 x 15'	4		120	Two Walls			
				1505	sq ft	x 2 =	3010	

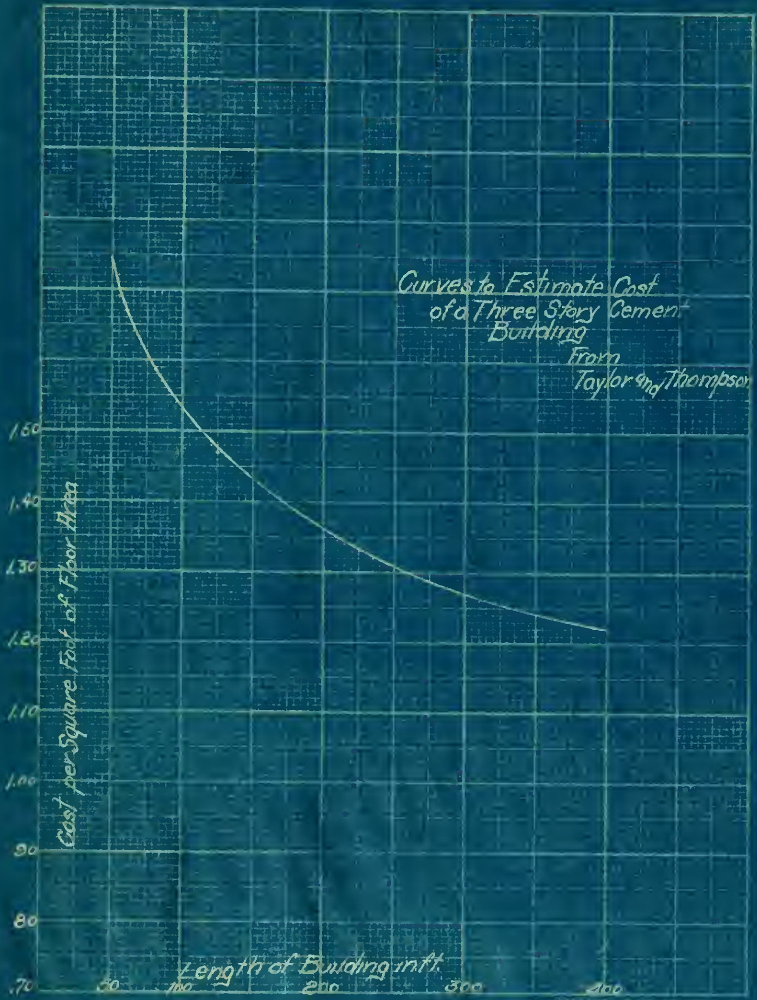
Floor	Dimensions	Number of Members	Ref Page	Material		Labor		Remarks
				Member	Total	Member	Total	
3	Curtain Walls North Wall + South Wall							
	1'-2"x 12'-4¾	2		31.2	31.2			
	1 x12'-4¾	8			107.5			
	3'-7¼x15'-1	2			117			
	3'-7¼x15'	4			230			Material
2	1'-2"x 9'-4"	2			23.6			Concrete 1:2½:5
	1'-0x 9'-4"	8			81			Cost 3.35 x 83.5 = 280
	1'-11"x 15'-1	2			68.6			Labor 1.83 x 83.5 = 150
	1'-11"x 15'	8			244			
1	1'-2"x12-4¾	2			31.05			
	1'x12'-4¾	8			107.5			
	10¼"x15'-1"	2			27.7			
	10¼"x 15'	4			54.5			
East +	West Curtain Walls				2247.30	cu ft =		83.5 cu yds
3	8"x12'-4¾"	4		35.7				Material 1:2½:5 Concrete
	6½x12'-4¾	12		85.8				Cost 3.35 x 149.5 = 501
	3'-7½"x15'-7"	2		122				Labor 1.83 x 149.5 = 273.6
	3'-7½x15'-4"	6		360				
2	8"x9'-4"	4		32				Total Cost of Labor
	6½ x9'-4"	12		65				and Mixing Plant Expenses
	1'-11"x15'-7"	2		64.6				$3472
	1'-11"x15'-4	6		191.0				Total Cost of Material
1	8"x12'-4¾	4		35.7				$7003
	6½x12'-4¾	12		86.8				
	10¼x15'-7"	2		28.8				
	10¼x15'-4	6		68.5	1757.3 x2 = 3514.6			For E + W. Walls multiply by 2
Pent House	3'-2"x1'-4"x10	4		18.7				
N + S Walls	18"x15'-4x10	2		38.5				
Walls 10¼	1"x15'-5x10	2		20.2	77.4 x 2 = 54.8			For N + S Walls multiply by 2
	3'-2"x10½x10¼	8		18.7				
	18"x14'-5½x10¼	4		73.6				
	1'-10"x14'-5x10	4		90.0	182.3 x2 = 364.6			
12 Panels	12'-9"x 12'-4¾"x 13" Brick				2060	3943.0 cu ft = 149.5 cu. yds		
6 "	12'-9"x9'-4"x 13" Brick				775			
	Total Cubic Yard in Building							= 50,139 cu ft / 27 = 1857 cu yd

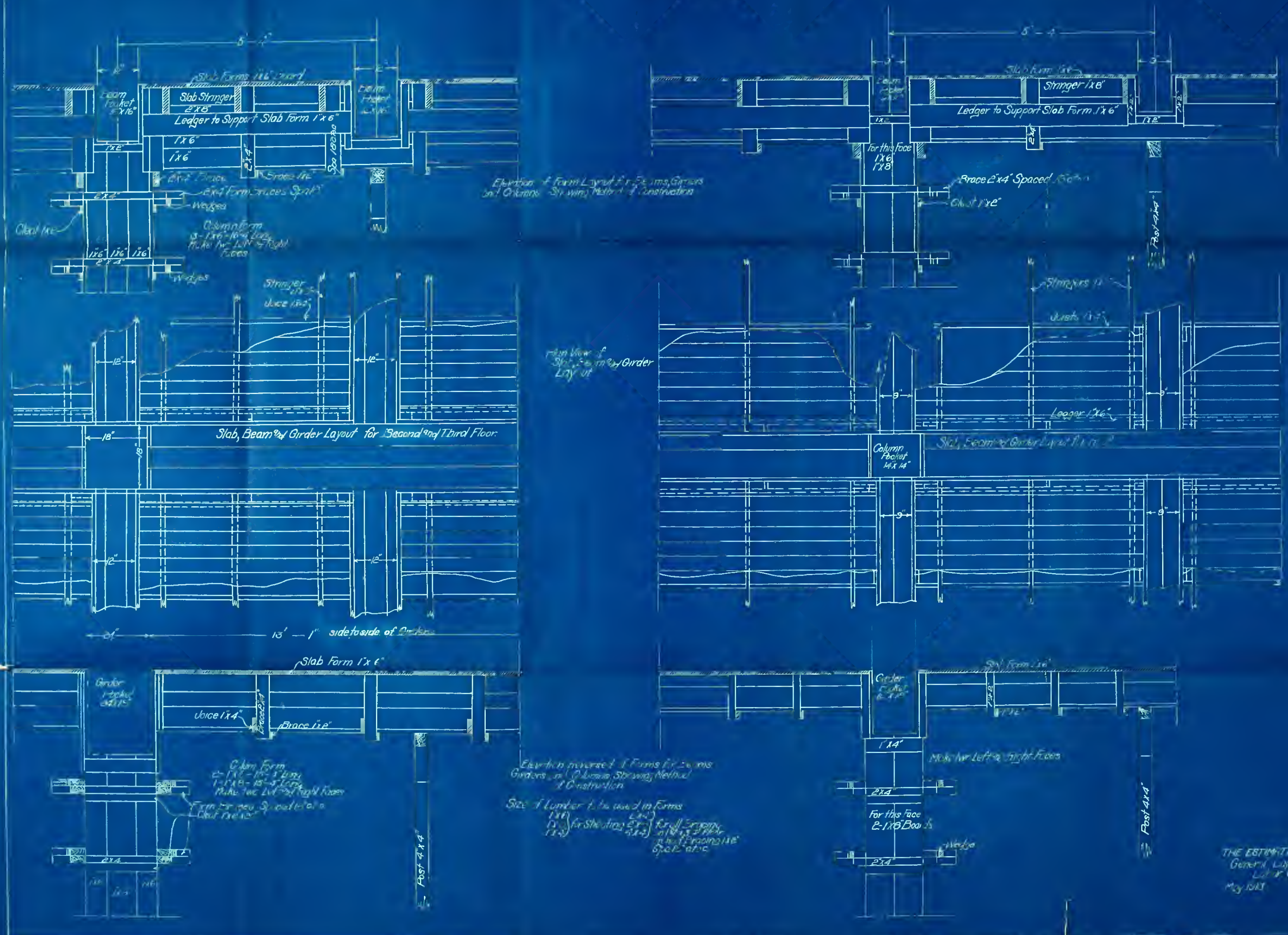
Summary Sheet

Steel Erected	$55.00/ton.	
Freight on Steel from Pitts. to Chi. .18¢/100		
Struct. Steel Rivets $2.20/c		
Struct. Steel Cost 340 Tons x $55.00		$18,700
Lumber Pine $36.00/1000 ft		
Lumber for Girders	$13,174	
" " Beams	22,514	
" " Columns	21,042	
" " Slabs	29,585	
Total B.M =	86,315 x $36.00 =	$3,107
Concrete Cost		
Total Cost of Material		$7,003
Total Cost of Mixing Plant Expense and Labor		3,472
Total Cost of Labor on Forms		7,300
Total Cost of Finishing and Waterbroofing		1,500
Total Cost of Reenforcing Floors		1,347
Brick Work		
Cost of Common Brick 42,000 @ $6.75/1000		$283
" " Labor @ $18.92/1000		795
Steel Fire Proof Windows on three sides		$3102
		$47,609
10% for profit		4761
Total Cost		$52,370

Cost per Square foot of Floor Area $1.475

Cost per Cubic Yard of Concrete $28.00/cu yd


Curves to Estimate Cost
of a Three Story Cement
Building
From
Taylor and Thompson
Cost per Square Foot of Floor Area
1.50
1.40
1.30
1.20
1.10
1.00
.90
.80
.70
Length of Building in ft.
50
100
200
300
400



Elevation of Form Layout for Beams, Girders and Columns Showing Method of Construction

Slab, Beam and Girder Layout for Second and Third Floor

Plan View of Slab, Beam and Girder Layout

Slab, Beam and Girder Layout

Elevation Reversed of Forms for Beams Girders and Columns Showing Method of Construction

Size of Lumber to be used in Forms
1"x6"
1"x8" } for Sheathing
1"x4"
2"x4"
2"x8" } for all Bracing
4"x4"
on 1st, 2nd & 3rd Floor
and Bracing 1"x6"
Specifications

THESIS
THE ESTIMATE COST OF R CONCRETE BUILDING
General Layout of Forms from which
Labor Cost on Forms was Estimated
Plate I
May 1913
George Henderson
J. L. Fennelly